Physics 471: Summary of Topics Covered in 1st Part of the Course
9/30/2008

Physical Concepts

1. Quantum mechanics is intuitively weird, as shown by 2-slit diffraction of electrons. The interference is destroyed by trying to measure which slit the electron went through.

2. The wavefunction is the probability amplitude to locate a particle in a region of space.

3. Ehrenfest's theorem: quantum mechanical expectation values obey classical mechanics.

4. The energy spectrum for bound states (e.g. square well or harmonic oscillator) is discrete – hence the name "quantum" mechanics

5. A particle can be in a linear superposition of more than one stationary state. In fact, since stationary states are inherently boring, all interesting dynamics occur in such linear superpositions.

6. When $\Psi(x,t)=\sum_{n=0}^{\infty} c_n \psi_n(x)\exp\left(\frac{-iE_n t}{\hbar}\right)$, the probability to measure energy E_n is $|c_n|^2$.

7. The energy spectrum for unbound particles is continuous; a particle cannot have a definite energy because the stationary states are not normalizable.

8. Wave packet spreading is a direct consequence of the uncertainty principle. The more you try to localize a free particle in space, the more its momentum is uncertain, hence the more the packet will spread over time.

9. When $\Psi(x,t)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}\Phi(k)\exp(ikx)\exp\left(\frac{-i\hbar k^2 t}{2m}\right)$, the probability to measure momentum $\hbar k$ is $|\Phi(k)|^2$.

10. Particles can pass through a potential barrier by quantum-mechanical "tunneling."

11. The harmonic oscillator is a special problem, due to the equal spacing of the energy levels. The raising and lowering operators take one from one state to another.

12. Quantum mechanical observables, such as position, momentum, and energy, are represented by operators. But we don't yet know what this means, or where it comes from. We'll find out more in Chapter 3!

Mathematical Concepts

1. Complex numbers and the mathematics of interference

2. Discrete probabilities and continuous probability densities

3. Expectation value and standard deviation of variables given their probability distributions

4. The concept of "orthogonal functions," e.g. Fourier series, or the stationary states of the harmonic oscillator. Expression of an arbitrary initial function as a linear superposition of orthogonal functions, and how to calculate the coefficients.

5. Use of symmetry to simplify integrals

6. Gaussian integrals

7. Fourier transforms

8. Solutions to linear 2nd order differential equations with boundary conditions

9. Approximate graphical solution to transcendental equations

10. Separation of variables technique for solving partial differential equations